"Results You Can Count On"

Model GHN-SP-UPLC

Universal Powerline Communications Splitter
For Physical-Layer Testing of
G.hn Devices Over Power Lines

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Model GHN-SP-UPLC

Customer Support

This document describes the Model GHN-SP-UPLC Universal Powerline Communications Splitter and related accessories.

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Please be sure to reference the RMA number on the outside container.

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Term Definitions

The following terms are used in the Cenelec PLC standards.

- Symmetrical: Value of a differential signal when measured between the two lines where it is present.
- Unsymmetrical: Value of a differential signal when measured on one of the two lines where it is present, in relation to its common mode value. In general terms, it is half the amplitude of the differential signal.
- Asymmetric: Common mode of a differential signal measured on the two lines in relation to the earth or ground potential. This is the part of the differential signal that gets converted to common mode due to the imbalance of the circuit, and which is susceptible of causing EMI.

SAFETY

- The UPLC contains an IEC power inlet which when connected to the Mains provides AC power to a European (Schuko) socket to provide filtered power to the products to be tested. The UPLC enclosure is Earth Grounded through the IEC Inlet and meets Personnel Safety Standards.

  DO NOT REMOVE OR LOOSEN ANY SCREWS ON THE ENCLOSURE OR SOCKETS

  DO NOT USE THE UPLC SOCKET AS A GENERAL POWER OUTLET

- The European non-polarized (Schuko) socket contains a Shutter which prevents separate entry into the Phase or Neutral lines. A safe adapter may be used to convert to other country power sockets. See the Adapter listing at the bottom of this section.

- The absolute maximum load is 1.25 amperes.

- Metal enclosed products that are inserted into the UPLC socket must be wire connected to the UPLC Earth Ground screw to provide Ground continuity safety to the product under test.

  CONNECT THE METAL ENCLOSURE OF PRODUCTS CONNECTED TO THE UPLC SOCKET TO UPLC EARTH GROUND SCREW TERMINAL FOR GROUND CONTINUITY

- The IEC Power Inlet contains a drawer with two fuses. To replace a fuse, disconnect the power cable from the power Inlet and open the Inlet fuse drawer.

  REPLACE THE GLASS FUSE WITH A 5-20mm, 1.25A fuse rated for 250VAC

  DO NOT USE A FUSE VALUE GREATER THAN 1.25A

  DO NOT ATTEMPT TO REMOVE OR REPLACE THE CERAMIC FUSE

SAFETY CONTINUED

- The fuse required is also identified on the UPLC at the Power Inlet.
- Replace and close the fuse holder in the IEC Power Inlet and reapply the power cable to the Power Inlet.
- Recommended list of Adapter Sockets that may be used to convert the European (Schuko) socket to local powerline requirements:

GHN-ADP_NA	North America Type B
GHN-ADP-CH_BR	Brazil, Switzerland
GHN-ADP-UK	United Kingdom
GHN-ADP-IT_RCH	Chiloe, Italy
GHN-ADP-AU_RCN_AR	Argentina, Australia, China

1.0 Overview

The Model GHN-SP-UPLC device is used to provide a controlled AC port to the PLC modem, separate and isolate the high-frequency PLC signal from AC power, and make it accessible on three BNC ports labelled L1 (Neutral), L2 (Earth) and L3 (Line) with a controlled impedance. Having the PLC signal on BNC ports allows the use of standard instruments and accessories to perform measurements and build controlled topologies. It performs Dynamic PSD Test and Cognitive Frequency Exclusion test (Dynamic Notching) per EN 50561-1 using Telebyte's Model 501 and 501-Probe-Coax.

1.1 Main Features

- Similar to AMN / LISN specified in CISPR-16, extending the concept to all three lines
- Suitable for all types of broadband MIMO PLC (not valid for narrowband PLC < 2 MHz)
- Basic building block for TR-208 and EN-50561 tests
- High performance AC filter which provides high isolation with similar common-mode and differential-mode impedance on each line, L1, L2 and L3
- Provides galvanic isolation and common-mode filtering to prevent PLC leakage on data port
- BNC connectors for High Frequency signals on L1, L2, and L3
- Embedded Zero-Cross Detector for AC-synchronized measurements and tests
- European Version (adapters for other country electrical Mains interface)
- Used with Telebyte Noise Generator for WT-208 testing
- Used with Telebyte Digital Analyzer for ITU-G.9964 PSD, CENELEC EN 50561-1, EN 50561-3 measurements

1.2 Model GHN-SP-UPLC Specifications

GHN-SP-UPLC Specifications	
Electrical Safety	Complies with EN 61010-1
Insertion Loss (Single Line)	EUT to BNC OUT (L1-L3): 0.35dB@ 80 MHz, 0.45dB@ 100 MHz
Differential Line Impedance	100 ohm +/- 10% (1MHz to 100 MHz)
Continuous Operating Voltage	90 to 240VAC, 50-60Hz
Outputs: L1, L2, L3	BNC-female Connector, 50 Ω Impedance, 1MHz to 100MHz

Specifications are subject to change without notice. Made in USA.

1.3 Ordering Options

MODEL	**DESCRIPTION**
GHN-SP-UPLC	Universal PLC Splitter with Schuko socket
GHN-ADP-CH_BR	Approved Power Adaptor for GHN-SP-UPLC (Switzerland, Brazil)
GHN-ADP-UK	Approved Power Adaptor for GHN-SP-UPLC (United Kingdom)
GHN-ADP-IT_RCH	Approved Power Adaptor for GHN-SP-UPLC (Italy, Chile)
GHN-ADP-AU_RCN_AR	Approved Power Adaptor for GHN-SP-UPLC (Australia, China, Argentina)
GHN-ADP-NA	Approved Power Adaptor for GHN-SP-UPLC (North America)
GHN-SP-SPLCOMB-UPLC-3	3-Channel Splitter/Combiner
GHN-AT-PROG-UPLC-3*	3-Channel Programmable Attenuator
1XBNCM-1XSMAM-1F*	BNC(male)-to-SMA(male) cable, length 1 foot
BNC-BNC-BARRELPLUG	BNC Plug-to-BNC Plug in-line barrel
BNC-TERM-50	50-ohm BNC Terminator
1XRJ45M-1XRJ45M-3F	Cat6 Shielded Patch Cable - SSTP Bare Copper, RJ-45 male connectors, length 3 feet

*Coming Soon

2.0 Model GHN-SP-UPLC

2.1 Introduction

The electricity distribution network exhibits a variable response over frequency in terms of impedance and insertion loss due to the nature of the constructive elements and the safety distances that must be observed. PLC systems overcome these variations using an OFDM modulation with variable bit loading in every carrier.

Emerging PLC certification standards impose clear-cut limits for conducted emissions, which require precision accessories providing low insertion loss, flat frequency response, and stable impedance. In addition, the use of the protective earth conductor for MIMO systems requires this line to be decoupled from the field ground in high frequency.

The GHN-SP-UPLC Universal Powerline Communications Splitter described in this document fulfills the requirements mentioned above, pushing the response of the device to the limits imposed by safety constraints.

The purpose of the device is separating the high-frequency PLC signal from AC power and making it accessible on three BNC ports named L1, L2 AND L3. Once the low-voltage PLC signal is separated from AC mains voltage, it can be handled safely using coaxial-based instruments and accessories.

This device is intended to build the setups required in the following standards:

EN 50561-1 Dynamic PSD test

EN 50561-1 Cognitive Frequency Exclusion test (Dynamic Notching)

WT-208 2, 3, and 4 node setups with attenuation and noise

In addition, it can be used to perform accurate PSD and dynamic range measurements.

2.2 Model GHN-SP-UPLC Testing Bundle

The GHN-SP-UPLC is sold separately or with accessories (as part of a testing bundle).

Table 2, below lists the contents of the Model GHN-SP-UPLC Testing Bundle.

Table 1: GHN-SP-UPLC Universal Powerline Communications Splitter Testing Bundle

Device	Amount	Figure
GHN-SP-UPLC Universal Powerline Communications Splitter	2	Figure 1
BNC-TERM-50 50Ω BNC Terminator	3	
1XRJ45M-1XRJ45M-3F Cat6 Shielded Patch Cable - SSTP Bare Copper, RJ-45 male connectors, length 3 feet	2	
GHN-SP-SPLCOMB-UPLC-3 3-Channel Power Splitter/Combiner	1	
BNC-BNC-BARRELPLUG BNC-Plug to BNC-Plug In-Line Barrel	3	

A brief description of each item is provided below:

- The GHN-SP-UPLC Universal Powerline Communications Splitter is the cornerstone of the Testing Bundle. This box feeds AC power to the PLC modem and delivers the PLC signal on three BNC ports L1, L2 and L3.
- The GHN-SP-SPLCOMB-UPLC-3 3-Channel Power Splitter/Combiner is plugged directly to the output ports of the GHN-SP-UPLC and equally divides or combines the signal power of each port to the other two ports. This accessory is used for measurements requiring the simultaneous use of auxiliary equipment.
- The 50Ω terminators are used to terminate unused ports in the GHN-SP-UPLC OR the 3-Channel Power Splitter/Combiner.
- The IEC power cords are used to supply the GHN-SP-UPLC from the mains network.

Figure 1: GHN-SP-UPLC Universal Powerline Communications Splitter

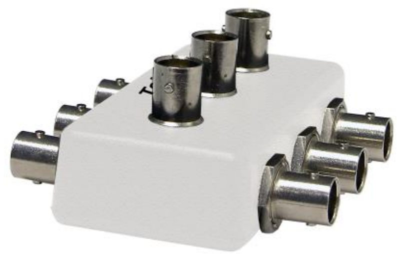


Figure 2: 3-Channel Power Splitter/Combiner

3.0 Model GHN-SP-UPLC Universal Powerline Communications Splitter

The splitter is divided into two parts:

Part 1

A signal-coupling network allows the high frequency PLC signals to reach the BNC connectors while blocking the low frequency AC supplies voltage. When power is applied to the UPLC-ZCD, the AC voltage in the live pin of an open BNC is attenuated to safe levels for the measurement instruments. When the BNC is loaded with 50Ω, this voltage drops to zero.

The advantage of using a capacitor without transformer is that the frequency response is almost flat and the impedance is reasonably constant. This type of coupling is in line with the measurement device proposed in prEN 50561-3.

Since all the PLC devices inject the signal differentially between lines, the impedance between any pair of lines seen from the modem is 100Ω, as it is the sum of the two 50Ω terminations.

Part 2

A low frequency filtering network allow AC signals to pass to the Schuko socket blocking any undesired high frequency signals while providing high isolation with similar common-mode and differential-mode impedance on all lines. The circuit is enclosed in a metal box that is connected to protective earth.

The splitter includes an Ethernet filter providing galvanic isolation and common-mode choking since the PLC signal usually leaks through the Ethernet port in many wall-plug PLC adapters.

4.0 GHN-SP-SPLCOMB-UPLC-3 3-Channel Power Splitter/Combiner

This device is a symmetrical power splitter and combiner where all the ports have 6 dB attenuation to each other.

The 3-Channel Power Splitter/Combiner provides one set of three BNC ports on one side and two sets on the other side. The spacing between connectors is the same as in the GHN-SP-UPLC Universal Powerline Communications Splitter, such that the device can be connected directly using male-male BNC barrels to reduce the number of cables.

- Unused ports of the 3-Channel Power Splitter/Combiner must be terminated with 50Ω.

5.0 Measurement Methods Across Standards

ITU-T G.9964 does not specify the procedure to measure the PSD injected by the PLC modem; it only specifies the PSD maximum limit and the termination impedance. The signal must be measured differentially, but there is no recommendation for MIMO devices.

CENELEC EN 50561-1 states that the PSD shall be measured symmetrically at various attenuations between EUT and AE (see EN 50561-1 Figure 4, section 9.2). The signal must be measured differentially because this standard is intended for SISO devices, using a balun to sadapt the impedance from 100Ω to 50Ω.

CENELEC prEN 50561-3 specifies the limit values for unsymmetrical signals measured on the lines, assuming a given symmetrical attenuation between modems. Compared to EN 50561-1, this standard proposes the measurement in single-ended mode (unsymmetrical), thus avoiding the use of a balun and the need to convert to symmetrical values. The measurement device proposed in prEN 50561-3 is aligned with the concept of the GHN-SP-UPLC Universal Powerline Communications Splitter. This standard covers only SISO devices, but the measurement method is suitable for MIMO.

Considering that prEN 50561-3 represents the most elaborate proposal regarding the measurement of PLC signals, the reasonable method would be converting G.9964 or EN 50561-1 limits to unsymmetrical values, so that the reading on each of the ports can be directly compared to the calculated limit.

In theory, the maximum allowed PSD of – 55 dBm/Hz should be equally divided among the three lines to obtain a fair limit that preserves the total power. However, the differential injection methods used in PLC modems impose that in a system with three lines only two MIMO modes can be used for transmission; otherwise there would be a net common-mode signal that would cause excess EMI. Therefore, the maximum PSD limit should be divided by 2 (decreased by 3 dB), and this limit should be imposed to every line. Note that this limit is irrespective of the transmission mode, SISO, or MIMO. When using MIMO, the additive power of the two ports on a given line cannot exceed this value.

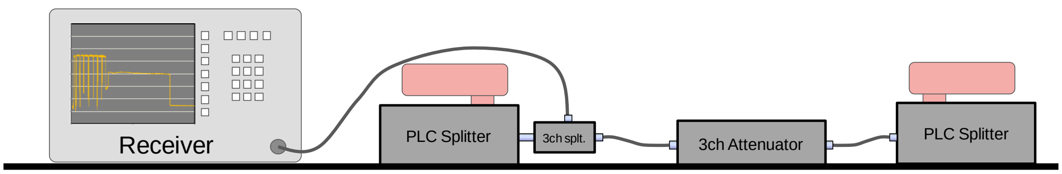
- When measuring the conducted PLC signal in voltage mode, the measurement must be increased by 6 dB due to the change in the reference impedance (from 100Ω differential to 50Ω single-ended). This same factor is used in prEN 50561-3 as conversion from unsymmetrical to symmetrical.

6.0 PSD Measurement Setup

Depending on the purpose of the measurement, the setup and the configuration of the spectrum analyzer differs. In all cases, the GHN-SP-UPLC can be used to effectively separate the PLC signal from the AC power with minimal deviation on the measurement.

It is recommended that the Universal Powerline Communications Splitters, the 3-Channel Power Splitter/Combiner, the attenuators, and the measurement equipment are placed on a metal plane to guarantee a uniform reference potential across the entire setup, as shown in Figure 3.

Figure 3: Reference Plane for Measurement Setup

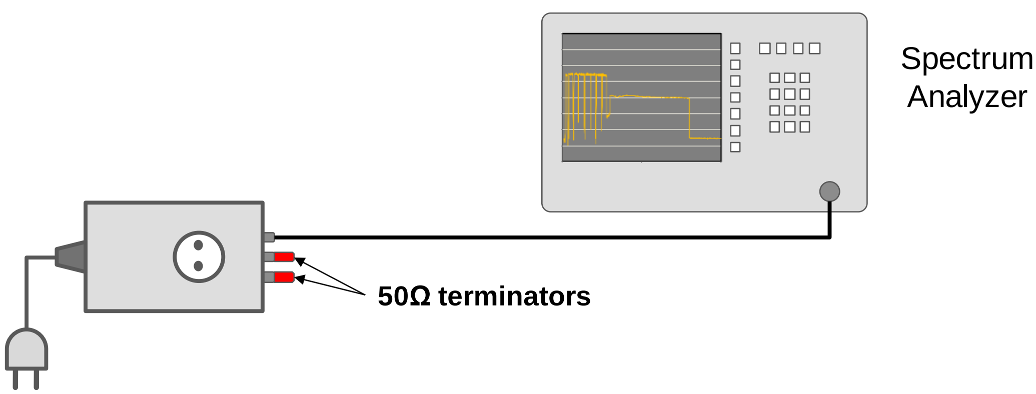


6.1 Measuring with a Single Unit

This procedure is suitable for modems that can autonomously generate a PLC signal without communicating to an auxiliary device.

The PLC modem must be plugged into the splitter and set in continuous transmission mode and in the corresponding operating mode (SISO or MIMO). Two of the BNC connectors must be fitted with 50Ω terminators, and the spectrum analyzer must be connected to the third one, as shown in Figure 4.

Figure 4: PSD Measurement with a Single Unit



If the device is MIMO, the measurement must be done at all the three ports since the levels may be different depending on the type of injection. If the device is SISO, it is recommended to perform this measurement at the L1 (Neutral) and L3 (Line) ports to confirm that there is no signal unbalance due to the construction of the modem. This procedure can be automated using an electronically controlled coaxial multiplexer.

- This method is only useful to check the maximum transmit PSD of a device, for example for ITU-T G.9964. CENELEC EN 50561-1 requires checking PSD at various attenuations between the EUT and the AE.

6.2 Measuring with Two Units

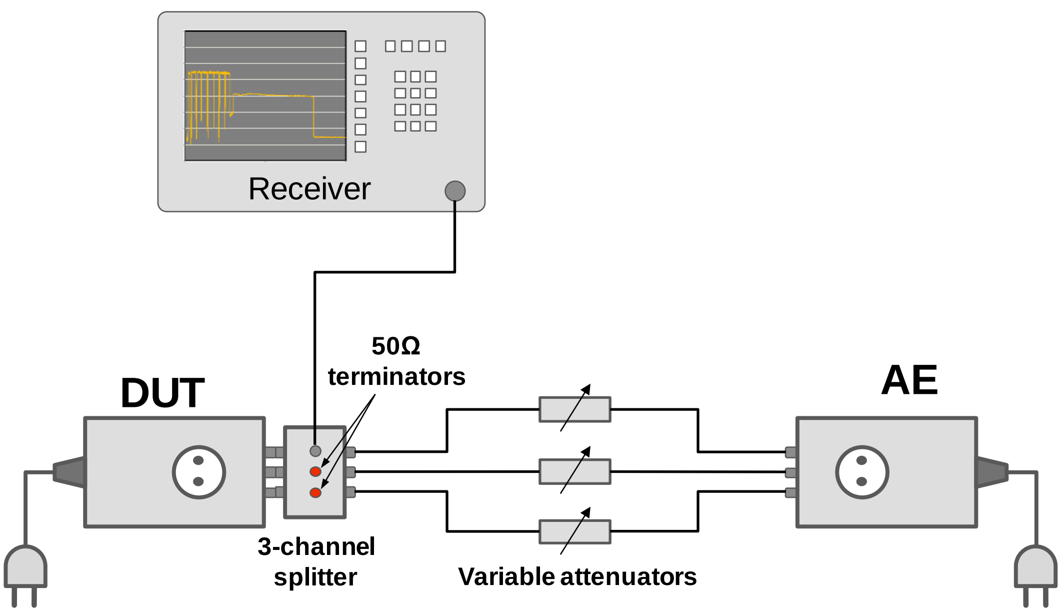
In case the PLC modem requires an auxiliary unit to transmit a signal continuously, the recommended setup is the one shown in Figure 5. A 3-Channel Power Splitter/Combiner is inserted in order to allow dividing the signal between the Auxiliary Equipment (AE) and the measurement instrument. Since only one port can be measured at a time, the unused ports must be fitted with 50Ω terminators.

The 3-Channel Power Splitter/Combiner included in the Testing Bundle is mechanically compatible with the Universal Powerline Communications Splitter, so that it can be attached to the output ports using male-male barrels, thus avoiding additional cables.

This measurement requires a traffic generator sending a data flow from the EUT to the auxiliary unit, so that the first one transmits the PLC signal with the highest possible duty cycle. If the traffic generator is not able to produce enough traffic to fill all the transmission time, the attenuation should be increased until the traffic exceeds the capacity of the channel. Most standards do not require full traffic load to check emission levels; the required channel occupancy is typically 10%; therefore, the traffic generator must be adjusted accordingly.

- The insertion loss of the 3-Channel Power Splitter/Combiner (6 dB) must be added to the value measured in the spectrum analyzer when the measurement is performed in voltage or power. The same value (6 dB) must be added to the attenuation between EUT and AE.

Figure 5: PSD Measurement with Two Units



6.3 Measuring with Two Units and Auxiliary Signals

CENELEC EN 50561-1 requires simulating the ingress of a radio communications signal to verify the dynamic frequency exclusion mechanism (section 6.2 of EN 50561-1). In this case, two devices are required plus a spectrum analyzer and a waveform generator. Figure 6 shows the suggested setup for this test.

The setup differs slightly from the one suggested in Figure 4 of EN 50561-1 because the balun has no resistive attenuator inside. The balun used for the test is built using a commercial wideband transformer. Figure 7 shows an example assembly.

EN 50561-1 requires the signal to be injected differentially between L1 (Neutral) and L3 (Line). However, it is not clear how the signal would be injected in a MIMO system. It is assumed that it can be injected in any combination of two ports, and the system should react equally. The value of the attenuators has been calculated to achieve the same values as required in EN 50561-1 for the SISO case.

EN 50561-1 requires an attenuation of 20 dB between the signal generator and the EUT. Considering that each 3-Channel Power Splitter/Combiner has a loss of 6 dB, an additional attenuation of 8 dB is required on the line (6 + 8 + 6 = 20 dB). The attenuation between EUT and AE is 6 dB plus the value of the variable attenuator.

The attenuation at the output of the signal generator depends on the device and type of signal and must be adjusted to the required levels before the test. The suggested value (40 dB) is based on the device and configuration explained in Section 0.

Figure 6: Setup for Dynamic Frequency Exclusion Test

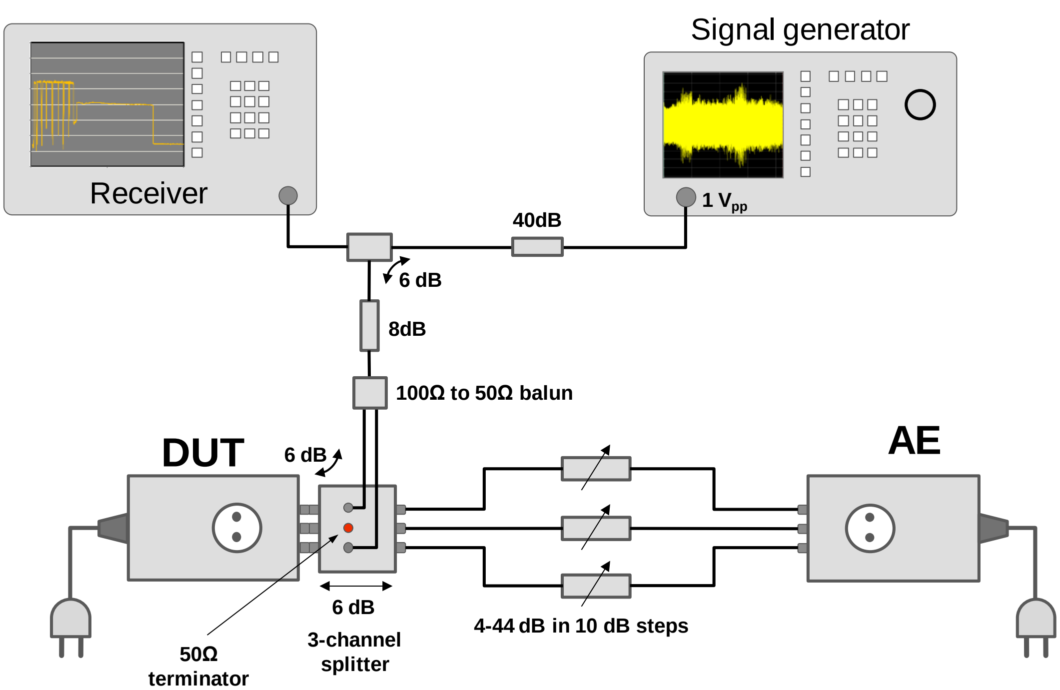
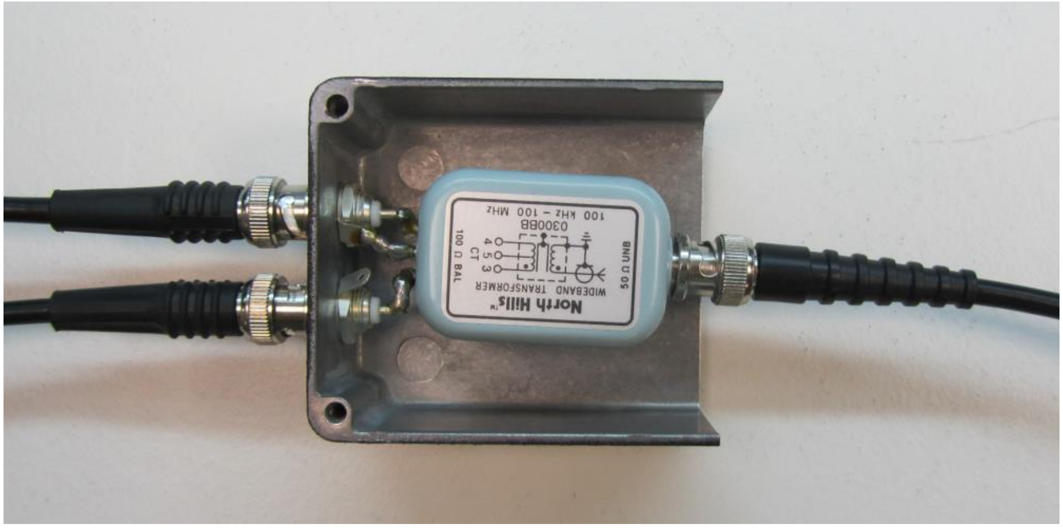


Table 2: Attenuation Between Elements in 2-Node Scenario

Path	Actual (dB)	EN 50561-1 Requirement (dB)
EUT to Receiver or Signal Generator	6 + 8 + 6 = 20	20
EUT to AE	Att + 6	10 to 50
AE to Receiver or Signal Generator	Att + 6 + 2 + 6 = (min 18)	20
Signal Generator to Receiver	6	6

Figure 7: 50Ω to 100Ω Balun (example assembly)



7.0 Multi-Node Scenarios

The GHN-SP-UPLC Universal Powerline Communications Splitter may be used in multi-node configurations such as the ones proposed by Broadband Forum and Home Grid Forum for Quality of Service and Neighboring Networks (see the BBF WT-208 document).

Using the GHN-SP-UPLC Universal Powerline Communications Splitter is the only way to build a technology-agnostic test bench. Due to the different ways to inject the second MIMO channel, splitters based on transformers that separate the differential signal between two lines are not usable because the pair of lines that are used is not known beforehand. The uncertainty is increased when using the CEE 7 plug, which is not polarized.

This section describes two basic configurations for 3 and 4 nodes. These scenarios can be easily extended to a higher number of nodes using the building blocks proposed in this document.

7.1 3-Node Scenario

This scenario is used for testing quality of service and data relaying through an intermediate node. The attenuation between the end nodes and the middle node must be controlled independently.

Figure 8: 3-Node Scenario

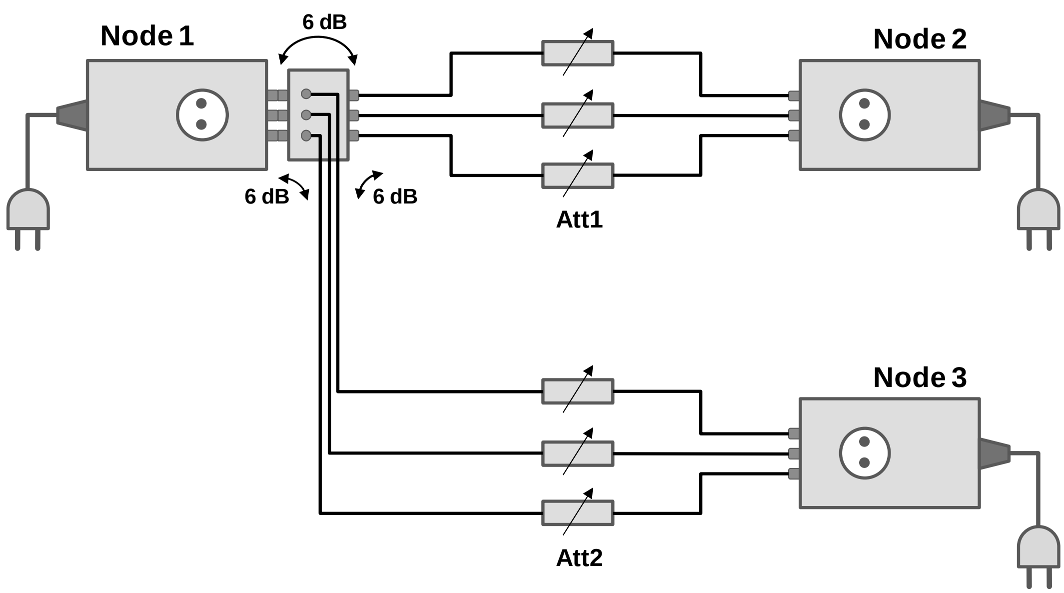


Table 3: Attenuation Between Elements in 3-Node Scenario

Path	Value (dB)
Node 1 to Node 2	Att1 + 6
Node 1 to Node 3	Att2 + 6
Node 2 to Node 3	Att1 + Att2 + 6

In some cases, forcing data relaying may require an attenuation of more than 100 dB between Node2 and Node3. Thanks to the excellent filtering and shielding of the GHN-SP-UPLC, complete isolation can be achieved.

- Remember to use the Ethernet filters included in the GHN-SP-UPLC Universal Powerline Communications Splitter to avoid signal leakage across Ethernet cables. This signal can be enough to establish a PLC link when the channel attenuation is set to values above 80 dB. The amount of leakage through the Ethernet port depends on the manufacturer's implementation.

7.2 4-Node Scenario

This scenario is used for testing Quality of Service and concurrent operation of neighboring networks. The attenuation between pairs of the same network and between networks must be controlled independently.

The topology presented in Figure 9 is the implementation that requires the minimum number of attenuators and combiners. However, the values of the attenuators are inter-dependent, and it may require solving some linear equations to calculate the values required for a given test. Some of the variable attenuators may be replaced with fixed attenuators.

Figure 9: 4-Node Scenario

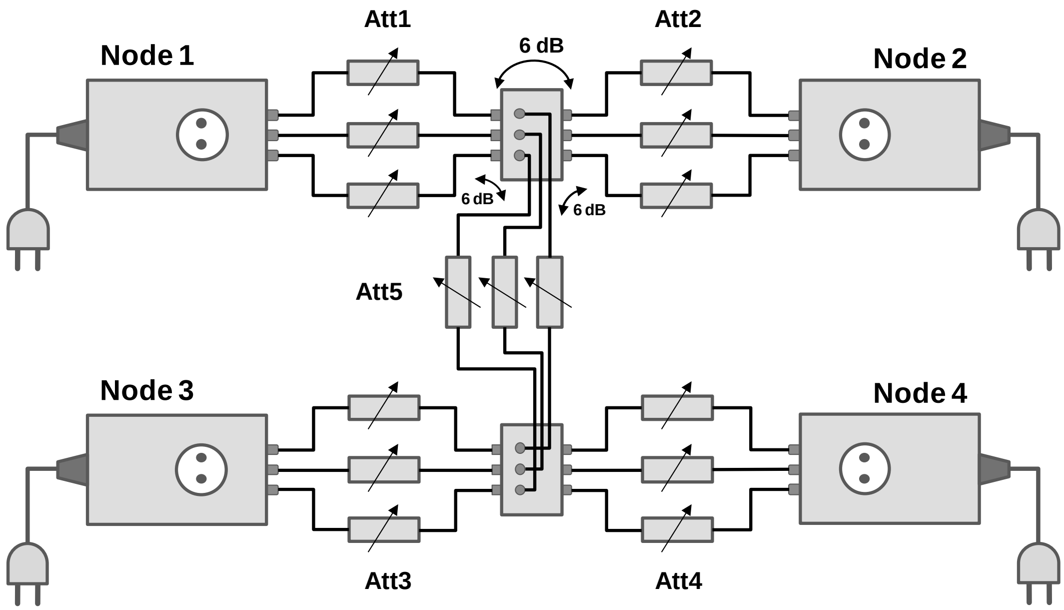


Table 4: Attenuation Between Elements in 4-Node Scenario

Path	Value (dB)
Node 1 to Node 2	Att1 + Att2 + 6
Node 3 to Node 4	Att3 + Att4 + 6
Node 1 to Node 3	Att1 + Att3 + Att5+ 12
Node 1 to Node 4	Att1 + Att4 + Att5+ 12
Node 2 to Node 3	Att2 + Att 3 + Att5 + 12
Node 2 to Node 4	Att2 + Att4 + Att5 + 12

8.0 PSD Measurement Procedures

8.1 True PSD Measurement

We consider a true PSD measurement the one performed such that it verifies Parseval's theorem, which states that the integral of the signal's power density spectrum must be equal to the integral of its RMS power in the time domain.

The measurement procedures suggested in CENELEC standards are typically oriented to evaluating the potential for an interfering signal to be noticeable by humans using analog systems, in particular analog radio communication receivers. The filters and detectors proposed in CISPR 16 date from the times of analog communications and have been inherited in newer standards.

Due to the nature of the OFDM signal (flat wide spectrum and relatively long, time bursts), the most appropriate detector is RMS, and the most convenient filter is the Gaussian one with bandwidth defined at -3 dB.

To measure PSD, any RBW filter is valid since the measured power is converted to power density dividing by the bandwidth of the filter. An RBW filter of 100 kHz is recommended for the whole band between 1 MHz and 100 MHz. Using narrower filters results in higher ripple in the measurement. For a system transmitting at full channel occupancy, a reliable PSD measurement can be performed using a sweep time of 5 seconds without using the Max Hold feature.

Table 5 shows the recommended configuration for the spectrum analyzer.

Table 5: SA Configuration for True PSD Measurement

Parameter	Value	Unit
Start Frequency	1	MHz
Stop Frequency	100	MHz
Resolution Bandwidth (RBW)	100	kHz
Video Bandwidth (VBW)	1000	kHz
RF Attenuation (analyzer-dependent)	40	dB
Sweep Time	5	s
Reference Level	10	dBm
Detector	RMS	
Vertical Scale	10/	dBm

Using the configuration proposed above, the conversion from analyzer reading to PSD would be as follows: PSD (dBm/Hz) = P(dBm) – 10·log(RBW) + IL

Where 10·log(RBW) is 50 and IL (Insertion Loss) is 6 dB if the splitter/combiner is used, and 0 dB otherwise.

Based on the explanation provided in Section 5.0, the resulting value should be checked against the following limits, for each line:

Table 6: PSD Limits in dBm/Hz with True PSD Measurement

	ITU-T G.9964	CENELEC EN 50561-1	CENELEC prEN 50561-3
f < 30 MHz	-58 dBm/Hz	-56.8 dBm/Hz	n/a
f > 30 MHz	-88 dBm/Hz	n/a	TBD

- The PSD limits for the CENELEC standards have been derived from the peak limits assuming an experimental conversion ratio to RMS. Note that all the above values are measured on a single line and do not represent the total power delivered from the PLC device.

8.2 EN 50561-1 Measurement

The PSD measurement according to section 6.1 of EN 50561-1 requires the setup shown in Figure 5. The configuration of the spectrum analyzer is shown in Table 7.

Table 7: Spectrum Analyzer Configuration for EN 50561-1

Parameter	Value	Unit
Start Frequency	1	MHz
Stop Frequency	30	MHz
Resolution Bandwidth (RBW)	9	kHz
Video Bandwidth (VBW)	100	kHz
RF Attenuation (analyzer-dependent)	40	dB
Sweep Time	5	s
Reference Level	100	dBµV
Detector	PK / AVG	
Vertical Scale	10/	dBµV

The EN 50561-1 standard imposes limits for average and peak values, both measured according to EN 55016-1 and with a minimum channel occupation of 10%. While the average value varies significantly with channel occupation (around 15 dB), the peak value stays rather constant between 10% and 100% occupation (for a detailed justification, see Appendix).

It is therefore assumed that the peak value is more constraining and independent of channel occupation, which is not easily adjustable in variable capacity technologies.

For an independent laboratory that is not familiar with the internal operation of the PLC device, it is easier to measure the peak value than the average value, just ensuring that there is a traffic level exceeding 10% of the nominal capacity of the device.

The measured value must be compensated as follows: V(dBµV) = Vmeas(dBµV) + IL where IL is the loss of the setup, namely 6 dB due to the 3-Channel Power Splitter/Combiner.

Knowing that the voltage measured on the ports is half the voltage present at the output of the modem, the EN 50561-1 limits shown in table 2 should be decreased by 6 dB (conversion from symmetrical to unsymmetrical). The limit values to compare with are the two lower rows of Table 8.

Table 8: Limit Voltage Values for EN 50561-1

Parameter	Value	Unit
Start Frequency	30	MHz
Stop Frequency	100	MHz
Resolution Bandwidth (RBW)	120	kHz
Video Bandwidth (VBW)	1000	kHz
RF Attenuation (analyzer-dependent)	40	dB
Sweep Time	5	s
Reference Level	100	dBµV
Detector	PK	
Vertical Scale	10/	dBµV

8.3 prEN 50561-3 Measurement

The setup presented in Figure 5 is also valid for measuring according to EN 50561-3. The setup using two Universal Powerline Communications Splitters plus the 3-Channel Power Splitter/Combiner is equivalent to the method proposed on the mentioned standard. Table 9 shows the configuration of the spectrum analyzer.

Table 9: Spectrum Analyzer Configuration for EN 50561-3

Parameter	Value	Unit
Start Frequency	30	MHz
Stop Frequency	100	MHz
Resolution Bandwidth (RBW)	120	kHz
Video Bandwidth (VBW)	1000	kHz
RF Attenuation (analyzer-dependent)	40	dB
Sweep Time	5	s
Reference Level	100	dBµV
Detector	PK	
Vertical Scale	10/	dBµV

EN 50561-3 directly imposes the use of Peak detector because the result is almost independent of the channel occupancy in case it is higher than 10%, as required in EN 55016-1 that is also applicable in this case.

The measured value must be compensated as follows: V(dBµV) = Vmeas(dBµV) + IL where IL is the loss of the setup, namely 6 dB due to the 3-Channel Power Splitter/Combiner.

Table 10: Limit Voltage Values for EN 50561-3

Detector	Method	Value	Unit
PK	Symmetrical on 100Ω	TBD	dBµV
PK	Unsymmetrical on 50Ω	TBD	dBµV

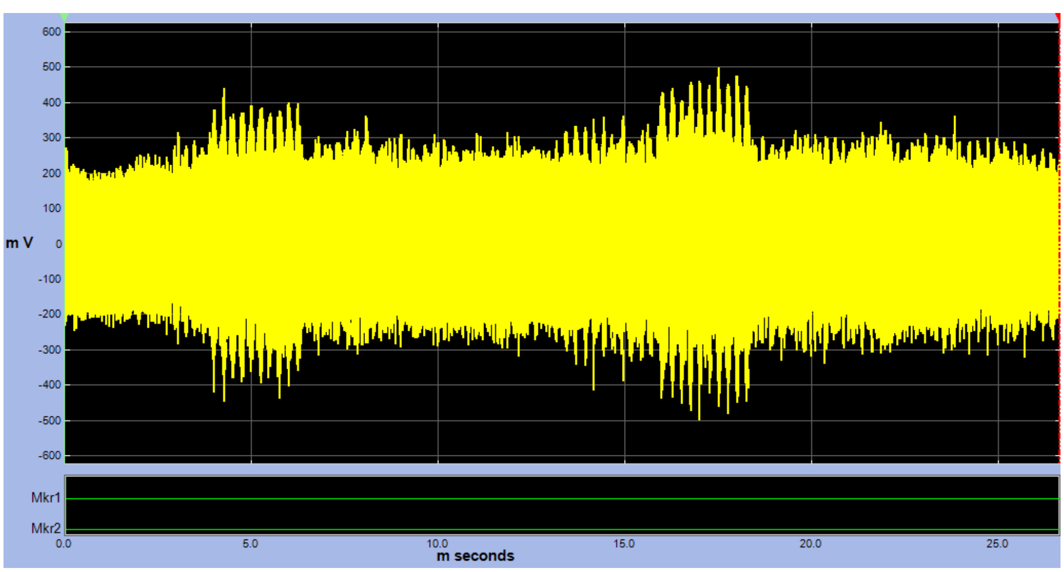
9.0 Dynamic Notching Measurement

Dynamic notching is the ability of a PLC modem to remove a portion of the spectrum of the transmitted signal if a narrowband radio station is detected. This feature is also referred to as dynamic frequency exclusion or cognitive frequency exclusion in EN 50561-1.

For further information about the setup required to perform this test using the GHN-SP-UPLC Universal Powerline Communications Splitter, see Section 6.3. The original setup is shown in Figure 4 of EN 50561-1. This figure is adapted from the ETSI TS 102 578, which extensively describes the measurement method.

The test signal proposed in the ETSI document is a large pattern containing 10 AM stations and 10 DRM stations, some of them with variable amplitude (see Figure 10). The size of the pattern is more than 2 million samples at 80 Msps, therefore a powerful arbitrary waveform generator is required. Re-sampling may be required to use the signal on some instruments. The duration of the test pattern is 26.7 ms, and it must be repeated cyclically.

Figure 10: ETSI TS 102 578 Test Signal for Dynamic Notching



A different test signal may be used according to EN 50561-1, provided that it contains a narrowband modulation in each of the 20 broadcast bands and a specific pattern of adjacent carriers as described in section C.4 of EN 50561-1.

A broadcast signal is considered detectable if it meets the following conditions when measured across two electrical lines w 100Ω impedance.

- 14 dB above the noise floor

  It can be assumed that the noise floor is the noise generated by the power supply of the modem that is usually tens of decibels below the requirements of EN 55022. There should be no other noise sources in a laboratory environment.

- -95 dBm power

  This is equivalent to a sine wave with an amplitude of 8 µV. This level can be achieved by using a 70 mV sine wave at the output of the generator and by adding a 40 dB attenuator in addition to the nominal 20 dB of the test setup.

- The test signal must meet the above criteria for at least 30 % of the time in any 10 s interval.

Table 11 lists the configuration of the spectrum analyzer for this test. The analyzer is used to verify that the PLC signal disappears when the broadcast signal is present.

Table 11: Spectrum Analyzer Configuration for Dynamic Notching

Parameter	Value	Unit
Center Frequency	Each of the carriers of the test signal	
Span	200	kHz
Resolution Bandwidth (RBW)	300	Hz
Video Bandwidth (VBW)	3	kHz
Detector	Average or Peak	

Table 12 lists the configuration of the arbitrary waveform generator for this test. The settings are based on a Tektronix AWG5012C and may vary if a different generator is used. An external 40 dB attenuator is required because the device cannot generate such a low voltage.

Table 12: AWG Configuration for Dynamic Notching

Parameter	Value	Unit
Test Signal	TS102578_v001p0	
Sampling Rate	80	MHz
Output Filter	100	MHz
Amplitude	0.5	V
Offset	0	V
External Attenuation	40	dB

The PLC signal must be removed from the excluded band 15 seconds after the activation of the test signal and remain disabled for 3 minutes after the removal of the test signal. The level of the PLC signal during the exclusion must be lower than -89 dBm as measured in the spectrum analyzer with the recommended setup. This level corresponds to EN 55022 Class B conducted emission limit measured unsymmetrically at the EUT port.

Appendix A: Conversion Factors

The relation between Average, RMS, Peak, and Quasi-peak values depends on the nature of the measured signal: Duty cycle, spectral occupancy, and frame structure. This section summarizes the experimental values calculated using ITU-T G.hn PLC technology.

Table 13 presents the drop of the measurements using different detectors relative to the maximum value with the peak detector. As seen from the table, the peak value changes slightly over the occupancy range by 10% to 100%. On the other hand, the average value is strongly dependent on the occupancy rate.

EN 50561-1 states that Peak and Average values must be measured. However, the difference between these readings is 10.8 dB at maximum occupancy, which is larger than the difference between Peak and Average in table 2 of the mentioned standard. This means that the Peak reading is the most restrictive limit in all cases, so the compliance inspection should start with this measurement.

Table 13: Differential Values as a Function of Channel Occupancy for f < 30 MHz

	Channel Occupancy (%)				
Detector	100%	75%	50%	25%	10%
Peak (PK)	0	0	-0.35	-0.6	-0.75
Quasi-peak (QPK)	-4.7	-4.7	-5.2	-5.8	-6.6
RMS	-9.25	-10	-12	-14.5	-17
Average	-10.8	-12.3	-16.2	-21.3	-26

This fact has been understood by the standardization committee, which motivates that the extension of the standard in EN 50561-3 imposes only the checking of the Peak value. However, the differential values are different for the band over 30 MHz due to the higher spectral content of the signal (fewer notches). Table 14 presents the differential values for this band.

Table 14: Differential Values as a Function of Channel Occupancy for f > 30 MHz

	Channel Occupancy (%)				
Detector	100%	75%	50%	25%	10%
Peak (PK)	0	0	-0.24	-0.5	-0.5
Quasi-peak (QPK)	-5	-5.2	-5.6	-6.2	-6.8
RMS	-10.9	-11.8	-13.8	-16.4	-18.9
Average	-12.5	-14.2	-17.9	-22.5	-26.3

Appendix B: Acronyms and Abbreviations

AC	Alternating Current
AE	Auxiliary Equipment
AM	Amplitude Modulation
BBF	Broadband Forum
BER	Bit Error Rate
CEE	Communauté économique européenne
CENELEC	Comité Européen de Normalisation Électrotechnique
CISPR	Comité International Spécial des Perturbations Radioélectriques
DRM	Digital Radio Mondiale
EUT	Equipment Under Test
IEC	International Electrotechnical Commission
ITU	International Telecommunications Union
MIMO	Multiple Input Multiple Output
OFDM	Orthogonal Frequency Division Modulation
PE	Protective Earth
PLC	Power line Communication
PLT	Power line Telecommunication
PSD	Power Spectral Density
RBW	Resolution Bandwidth
RF	Radio Frequency
RMS	Root-Mean-Square
SISO	Single Input Single Output
VBS	Video Bandwidth